Factors influencing epiphytic bryophyte and lichen communities at different spatial scales in managed temperate forests and an experimental study of regeneration of epiphytic bryophyte communities

PhD thesis

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1 Introduction and aim of study

Two studies investigating the cryptogam epiphytic communities in Őrség National Park are presented in my PhD thesis.

1.1 Factors influencing epiphytic bryophyte and lichen communities at different spatial scales in managed temperate forests

Factors influencing epiphytic bryophytes and lichens were investigated in the framework of Őrs–Erdő Project (head of project: Dr. Péter Ódor). In this project several groups of forest organism were studied, in 35 forest stands.

The aim of the study introduced in my dissertation is to define factors influencing species richness and composition of epiphytic bryophyte and lichen communities at two different spatial scales.

1. On *stand level* the studied factors were tree species composition, stand structure, light conditions, microclimate, and historical and landscape variables.
2. On *tree level* tree species, diameter at breast height and light were analyzed.

Species composition and species richness of bryophytes and lichens were examined both on stand and tree level. On stand level species richness of specialist epiphytic bryophytes and forest specialist lichens were also analyzed. Special attention was paid on the effect of host tree species on bryophyte species.

Beside the general exploration of relationships between environmental factors and epiphyte species richness and composition, this study aimed at improving forest biodiversity conservation in the studied region.

1.2 An experimental study of regeneration of epiphytic bryophyte communities

In the next section of my dissertation a study investigating regeneration of epiphytic bryophyte communities after experimental disturbance was introduced. The study aimed at exploring natural dynamics of epiphytic bryophyte communities and at investigating effect of disturbance (removing) on species richness and composition.

1. How much time does the regeneration of species richness and cover take?

2. Is the regenerated species composition similar to the original one or not? Does the disturbance support colonization of new species?
3. Is the exposed area recolonized from residual plant parts or aerially dispersed diaspores?
4. How does disturbance influence survival, disappearance and colonization of the species?
5. As control, dynamics of intact communities was studied.

2 Material and methods

2.1 Factors influencing epiphytic bryophyte and lichen communities at different spatial scales in managed temperate forests

2.1.1 Data collection

The study area was in Őrség National Park (N 46°51'–55' and W 16°07'–23') at the westernmost part of Hungary. Thirty-five stands were selected; inclusion criteria of site selection were as follows: dominant trees older than 70 years, more or less level slope, absence of ground-water influence and spatial independence of sites (the distance was minimum 500 m between the stands), and the characteristic tree species combinations of the region is represented.

Within each stand, a 40×40 m^2 plot was pointed out for stand structural measurements. Epiphytic bryophytes and lichens were recorded in 30×30 m^2 plots positioned in the middle of the 40×40 m^2 plots. The cover of bryophyte and lichen species was recorded in every living tree with minimum 20 cm DBH from the bottom to 1.5 m height.

2.1.2 Data analyses

The two communities were analyzed separately both on stand and tree level. Factors influencing species composition were explored by indirect ordination methods (principal component analyses and detrended correspondence analyses) and direct ordination methods (redundancy analyses and canonical correspondence analyses). Linear regression models were built to examine factors influencing species richness. Indicator species analysis was carried out to study host preference of bryophyte species.

2.2 An experimental study of regeneration of epiphytic bryophyte communities

2.2.1 Data collection

Regeneration of epiphytic bryophyte communities was followed up on eight, 95 years old sessile oak trees (*Quercus petraea*) in a ca. quarter hectare large patch in the forest stand Csörötnek 43/B (EOV longitude 444791, EOV latitude 179990).

Paired annular samples were laid out in height 0.5-1.5 m from the bottom of the trees. They were 20 cm wide with 10 cm between them. Bryophyte species composition was ca. the same in the paired samples at the beginning of the experiment. Bryophyte cover were removed from one member of the pairs, the others were intact (as a control).

The sites were monitored annually during four years. The annular samples were divided in 4 cm × 4 cm microquadrates. Presence and absence of species were recorded within the microquadrates and in the grid points. Bryophyte cover was removed immediately after recording the baseline. Analyses were carried out on the dataset obtained from four yearlong monitoring.

2.2.2 Data analyses

Data of microquadrates were used to explore dynamics of species richness and composition, as well as to study dynamic characteristics of the species. Data of grid points were used to examine dynamics of cover. Intact and disturbed samples were analyzed separately. Data were summarized by descriptive statistics.

3 Results

3.1 Factors influencing epiphytic bryophyte and lichen communities at different spatial scales in managed temperate forests

3.1.1 Tree species composition, host tree species

Bryophyte community, bryophyte species

Tree species was the most important factor both on stand and tree level. On stand level diversity of tree species composition increased bryophyte species richness. On tree level more than one third of the bryophyte species was strongly associated to one of the tree species.

Bryophyte species composition was determined first of all by oak proportion on stand level. Most of the bryophyte species were associated to oak trees also on tree level. Specialists and facultative epiphytes forming wefts and mats mainly colonized oak trees.

Beech was preferred by some cushion-forming species (*Orthotrichum* species, *Ulota crispa*).

Pines were avoided by all bryophyte species.

Lichen community

Tree species was the most important factor both on stand and tree level. Tree species diversity was important both for lichen species richness and composition. Hornbeams played a prominent role in lichen species richness; oaks were the second most important tree species for lichens. Pines were avoided by lichens generally, however some acidofrequent species were associated to them.

3.1.2 Stand structure, tree size

Bryophyte community, bryophyte species

On stand level stand structure was similar of importance like tree species composition. Mean of DBH affected bryophyte species composition: density of big trees increased bryophyte species richness and species richness of specialist bryophytes. Shrub density increased species richness, while tree density influenced it negatively.

On tree level effect of tree size was much lower than tree species, however, DBH effect on bryophyte species richness was strong in case of broad-leaved tree species.

Lichen community

On stand level lichen community was much less influenced by stand structure than tree species composition. Density of shrub layer had a positive effect on species richness, especially in stands dominated by oaks.

DBH was much less important than tree species also on tree level. DBH effect increased lichen species richness, except for pines and hornbeams.

3.1.3 Microclimatic factors: light, humidity and temperature

Bryophyte community, bryophyte species

Effects of microclimatic factors were far less strong than those of tree species composition and stand structure at both studied spatial scales. On stand level air humidity increased species richness, while daily mean temperature influenced species composition. Air humidity correlated with shrub density significantly.

On tree level light effect was weak.

Lichen community

Light had very strong effect on lichen communities.

On stand level amount of light influenced species composition. Species richness increased with amount of light and heterogeneity of light conditions. Light effect on species richness of forest specialist lichens was of same importance as tree species.

On tree level light effect was of same importance as DBH effect. It increased lichen species richness on tree species, except for hornbeams.

3.1.4 Historical and landscape-scaled factors

Historical and landscape factors did not prove to be important for both studied organism groups. Proportion of forest in the landscape had a weak effect on bryophyte species composition.

3.2 An experimental study of regeneration of epiphytic bryophyte communities

Species richness reached 70% of the original species richness in the fourth year, and the species richness curve function of time saturated. 55% of the original cover has been regenerated after four years, and cover increased as a linear function of time.

Species composition approximated its original state continuously. Mainly the abundance of originally existing species changed, whilst colonization of new species was very rare. Lateral encroachment from the intact zone was not important.

Considering the species turnover, for the third year rates of survival, disappearance and colonization were the same as in the intact zone. This trend continued in the fourth year as well.

Frequency of species changed also in intact zone, but there was not a trend as it was in disturbed zone. Considering species turnover, there were outliers of survival, disappearance and colonization in the second year.

4 Conclusions

4.1 Factors influencing epiphytic bryophyte and lichen communities at different spatial scales in managed temperate forests

Tree species composition and host tree species have primary importance almost for all studied variables of bryophytes and lichens. In case of bryophytes stand structure has a similar importance, while in case of lichens light is the second most influencing factor. Historical and landscape factors did not prove to be important for both studied organism groups.

Bryophyte community, bryophyte species

Bryophyte species have a remarkable tree species preference in the studied region. They prefer broad-leaved trees to conifers presumably because their bark is richer in nutrition. Bark of oaks furrowed with deep wrinkles provides a lot of moist microhabitats, which support existing a species-rich community. Smooth bark of beeches is dryer, so they are colonized only by some cushion-forming, more desiccation-tolerant species. Pines have dry bark with loose flaked surface not appropriate for a permanent bryophyte cover.

Old, large trees have a key role in diversification of epiphytic bryophyte communities in the region. Besides of the simple area effect it is also explained by higher habitat (bark) diversity of old trees, and by the elongated colonization time, which is crucial for the dispersal-limited species.

Beside the humidity, shrub density was a marked factor in results, so we think that these factors are closely interconnected. Shrub layer provide humid, shady microclimate in the studied zone (0–1.5m), which support vegetative and reproductive processes of bryophyte species.

In contrary, the observed negative effect of tree density is apparently due to creating a second canopy layer, which does not increase humidity in the studied zone, but inhibits growth of shrub layer because of obstructing light.

Effect of forest proportion can be explained directly by metapopulation dynamics. There might be other indirect factors behind forest cover which need further studies.

Lichen community

Similarly to bryophytes, lichen communities are also determined first of all by tree species composition. Forests with diverse tree species composition maintain diverse lichen communities. The key role of hornbeams in lichen species richness and composition is probably due to the lack of competition with bryophytes. Oak proportion had a positive impact for the community variables examined, but in all case it was secondary to the importance of light, for which lichens showed a higher sensitivity than bryophytes. In stands where canopy is dominated by oaks the light is sufficient to maintain a rich shrub layer, which positively influences lichen communities per its humidity-retaining effect.

4.2 An experimental study of regeneration of epiphytic bryophyte communities

A fine-scale secondary succession was investigated. Results were obtained only on the basis of four years of data, which, at successional time scale, is only suitable to draw preliminary conclusions.

Species richness regenerates very quickly after disturbance, but cover regenerates more slowly. Based on the literature, the complete recovery can take several decades.

From changes of species composition and field experience we conclude that the exposed area was recolonized from residual plant parts, the role of lateral encroachment and aerially dispersed diaspores was negligible.

In the case of intact zone changes were bigger than expected. This can be explained by recent disturbances of the stand, which changed light and microclimatic conditions.

5 Publications forming the base of PhD thesis

5.1 Articles published in peer-reviewed journals with impact factors

Király, I., & Ódor, P. (2010). The effect of stand structure and tree species composition on epiphytic bryophytes in mixed deciduous-coniferous forests of Western Hungary. *Biological Conservation*, *143*(9), 2063–2069.

Király, I., Nascimbene, J., Tinya, F., & Ódor, P. (2013). Factors influencing epiphytic bryophyte and lichen species richness at different spatial scales in managed temperate forests. *Biodiversity and Conservation*, *22*(1), 209–223.

Ódor, P., Király, I., & Tinya, F. (2013). Patterns and drivers of species composition of epiphytic bryophytes and lichens in managed temperate forests. *Forest Ecology and Management*, *306*, 256–265.

Tinya, F., Márialigeti, S., Király, I., Németh, B. and Ódor, P. 2009. The effect of light conditions on herbs, bryophytes and seedlings of temperate mixed forests in Őrség, Western Hungary. Plant Ecology 204: 69-81.

5.2 Conference proceedings

1. Ódor, P., Tinya, F., Márialigeti, S., Mag, Zs. és Király, I. 2008. A faállomány és különböző erdei élőlénycsoportok kapcsolata az őrségi erdőkben. Előadás. 3. Kvantitatív Ökológiai Szimpózium. Budapest. Összefoglalók, p. 22.
2. Király, I. és Ódor, P. 2008. A faállomány változóinak hatása az őrségi erdők kéreglakó mohaközösségére. Poszter. V. Magyar Természetvédelmi Biológiai Konferencia. Nyíregyháza. Összefoglalók p. 125.
3. Ódor, P., Tinya, F., Márialigeti, S., Mag, Zs. és Király, I. 2008. A faállomány és különböző erdei élőlénycsoportok kapcsolata az őrségi erdőkben. V. Magyar Természetvédelmi Biológiai Konferencia. Nyíregyháza. Összefoglalók p. 137.

4. Ódor, P., Király, I., Mag, Zs., Márialigeti, S. és Tinya, F. 2009. A faállomány hatása különböző élőlénycsoportok összetételére és diverzitására az őrségi erdőkben. Előadás. 8. Magyar Ökológus Kongresszus. Szeged. Összefoglalók p. 166.
5. Ódor, P., Márialigeti, S., Mag, Zs., Lengyel-Király, I. and Tinya, F. 2009. The effect of stand structure on different organism groups in mixed deciduous-coniferous forests in Hungary. Oral presentation. 2nd European Congress of Conservation Biology. Prague. Book of Abstracts p. 97.
6. Király, I. and Ódor, P. 2009. The effects of stand structure on epiphytic bryophytes. Poster presentation. 2nd European Congress of Conservation Biology. Prague. Book of Abstracts p. 189.
7. Király, I., Márialigeti, S. és Ódor, P. 2010. A faállomány és a mohaközösség kapcsolata az őrségi erdőkben. Előadás. „Aktuális eredmények a kriptogám növények kutatásában” konferencia. Eger. Összefoglalók: http://termeszettudas.ektf.hu/index.php?page=program-botanika-hete-pentek
8. Ódor, P., Király, I., Mag, Zs., Márialigeti, S., Nascimbene, J., Tinya, F., Bidló, A. 2011. A faállomány hatása különböző élőlénycsoportok fajgazdagságára és faji összetételére az őrségi erdőkben. Előadás. Kari Tudományos Konferencia. A konferencia előadásainak és posztereinek kivonata. Nyugat-magyarországi Egyetem Erdőmérnöki Kar, Sopron. p. 40.
9. Ódor, P., Nascimbene, J., Lengyelné Király, I., Bortington, F. 2011. Faállomány hatása az epifiton mohák és zuzmók diverzitására és összetételére az őrségi erdőkben. Poszter. VII. Magyar Természetvédelmi Biológiai Konferencia, Debreceni Egyetem, Debrecen. Program és Absztrakt Kötet p. 144.
10. Ódor, P., Nascimbene,J., Lengyelné Király, I. 2012. Faállomány hatása az epifiton mohák és zuzmók diverzitására és összetételére az őrségi erdőkben. Poszter. Aktuális flóra- és vegetációkutatás a Kárpát-medencében. Kitaibelia 17(1): 130.
11. Ódor, P., Király, I., Márialigeti, S. 2012. Effect on stand structure on the diversity of epiphytic and ground-floor bryophyte assemblages in Hungarian mixed forests. Oral presentation. 8th Conference of European Comitee for Conservation of Bryophytes, Budapest, Hungary. Book of Abstracts p. 24. http://eccb_bryo8.nhmus.hu/
12. Ódor, P., Bidló, A., Király, I., Kutszegi, G., Lakatos, F., Zs, M., Tinya, F. (2012). A faállomány és az erdei biodiverzitás összefüggései több élőlénycsoportra vonatkozóan. In S. Bartha & K. Mázsa (Eds.), *9. Magyar*

Ökológus Kongresszus (80). Vácrátót: MTA ÖK Ökológiai és Botanikai Intézet.

13. Ódor, P., Király, I., Zs, M., Márialigeti, S., Nascimbene, J., Tinya, F., & Bidló, A. (2012). A faállomány hatása különböző élőlénycsoportok fajgazdagságára és faji összetételére az őrségi erdőkben. In: Lakatos, F. & Szabó Z. (Eds.), *Kari Tud. Konf. Kiadvány*, Sopron: NyME (p. 40).
14. Ódor, P., Király, I., Tinya, F., Bortignon, F., & Nascimbene, J. (2013). Epifiton mohák és zuzmók faji-összetételét és diverzitását meghatározó tényezők az őrségi erdőkben. In: Pénzesné Kónya E. (szerk.) II. Aktuális eredmények a kriptogám növények kutatásában Konferencia, Eger (p. 9.)

5.3 Further publications related to the dissertation

1. Ódor, P., Tinya, F., Márialigeti, S., Mag, Zs. és Király, I. 2011. A faállomány és különböző erdei élőlénycsoportok kapcsolata az őrségi erdőkben. Erdészeti Lapok 146(1): 23-26.